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CHAPTER 1.

Introduction

The goal of this document is to help states develop and use biocriteria for streams and small rivers. The document includes a general strategy for biocriteria development, identifies steps in the process, and provides technical guidance on how to complete each step, using the experience and knowledge of existing state, regional, and national surface water programs.

Purpose:
To provide conceptual guidance on how and when to use the biosurvey-biocriteria process to evaluate streams and small rivers.

This guidance document is designed primarily for water resource managers and biologists familiar with standard biological survey techniques and similarly familiar with the EPA guidance document "Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish" (Plafkin et al. 1989). It should be used in conjunction with that earlier text.

The biosurvey-biocriteria process provides a way to measure the condition of a water resource, that is, its attainment or nonattainment of biological integrity. In turn, biological integrity is a conceptual definition of the most robust aquatic community to be expected in a natural condition — in a water resource unimpaired by human activities. Thus, biological criteria are the benchmarks for water resource protection and management; they reflect the closest possible attainment of biological integrity. It follows that any criterion representing less than achievable biological integrity is an interim criterion only, since the use of biocriteria are intended to improve the nation's water resources.

The guidance in this document is designed so that users may tailor the methods to their particular biocriteria development needs. Chapters 1 and 8 are inclusive of the methodology — at different levels of complexity — while chapters 2 through 7 explore the process step by step. Thus, the document is organized as follows:

- **Chapter 1:** Introduction. An overview of the process.
- **Chapter 2:** Components of Biocriteria. An exploration of the basic relationship between biological integrity and biocriteria, the complex nature of human disturbances, and the definition of biological expectations.
- **Chapter 3:** The Reference Condition. Selection of reference sites and the role of the reference condition in biocriteria development.

- **Chapter 4:** Conducting the Biosurvey. An investigation of the design, management, and technical issues related to biocriteria-bioassessment programs, the various biosurvey methods and their standardization.
- **Chapter 5:** Evaluating Environmental Effects. Factors that affect water resource integrity.
- **Chapter 6:** Multimetric Assessment Approaches for Biocriteria Development. Emphasis on the community composition element of biological surveys.
- **Chapter 7:** Biocriteria Development and Implementation. Designing and developing biocriteria from the data and precautions for some site selections.
- **Chapter 8:** Applications of the Biosurvey-Biocriteria Process. Case Studies from North Carolina, Ohio, Delaware, and Maine.

Each chapter concludes with a list of readings containing supplemental information on the specific topic treated in that chapter. An extensive glossary and full reference list appear at the end of the document. Future documents will be oriented to other waterbody types: lakes and reservoirs, rivers, estuaries near coastal marine waters, and wetlands.

The Concept of Biocriteria

Biocriteria are developed from expectations for the region or watershed, site-specific applications, and consensus definitions by regional experts. The biological sampling for this process requires minimally impaired reference sites against which the study area may be compared.

Early efforts to monitor human effects on waterbodies in the 18th century were limited to physical observations of sediment and debris movement resulting from land settlement, and commercial activities (Caper et al. 1983). Later, as analytical methods became increasingly available for measuring microchemical conditions in the waterbody (Gibson, 1992), chemical measurements became the most commonly employed source of water quality criteria. However, investigators and resource managers have long recognized that such water column measurements reflect conditions only at the time of sampling.

To understand fully the effects of human activities on water resources, biological sampling is an important supplement to chemical sampling. Biological measurements reflect current conditions as well as temporal changes in waterbodies, including the cumulative effects of successive disturbances.

Three aspects of water resource management (chemical, physical, and biological) are recognized in the National Clean Water Act as amended by the Water Quality Act of 1987 (U.S. Gov. Print. Off. 1988). Section 101a states that the Act's primary objective is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters."

The development and widespread use of formal biological criteria (biocriteria) has lagged behind chemical-specific, in-stream flow, or toxicity-based water quality criteria in waterbody management (U.S. Environ. Prot. Agency, 1985a,b; 1986). Biological criteria are numeric values or narrative expressions that describe the preferred biological condition of aquatic communities based on designated reference sites. The conditions of aquatic life found at these reference sites are used to help detect both the causes and levels of risk to biological integrity at other sites in the

same region. In keeping with the policy of not degrading the resource, the reference conditions — like the criteria — are expected to be upgraded with each improvement to the water resource. Thus, biocriteria contribute directly to water management programs, and recent recommendations (U.S. Environ. Prot. Agency, 1987a,b) on monitoring strategies for aquatic resources have emphasized the need to accelerate the development of biological sampling as a regular part of surface water programs.

Biocriteria are developed from expectations for the region or watershed, site-specific applications, and consensus definitions by regional authorities. The biological sampling for this process requires minimally impaired reference sites against which the study area may be compared. Minimally impaired sites are not necessarily pristine; they must, however, exhibit minimal disturbance (i.e., human interference) relative to the overall region of study.

Applications of Biocriteria

Biocriteria applications are presented in some detail in chapter eight. Here, a brief description of these applications is sufficient to demonstrate the usefulness of the concept.

■ **Aquatic Life Designated Uses.** The States and Tribes together with EPA identify the most appropriate uses of our water resources and then manage or restore these waters accordingly. Some aquatic life uses are cold water fisheries, warm water fisheries, unique natural systems, and systems including rare or endangered species. Biological assessments and subsequent criteria are essential to the development and refinement of these designations and the management necessary to support them.

■ **Problem Identification.** Biological surveys and their comparison to established biological criteria, in addition to traditional chemical and physical investigations, often provide insights into problems not otherwise identifiable. For example, new compounds or synergistic reactions between existing waterborne chemicals may affect the biota even though individual chemical tests show no rise in historic concentrations; hydrologic modifications such as installed impoundments may restrict species distribution and recruitment; increased watershed sealed surfaces may change flow regimes, cause more scouring, and destroy habitat for essential community assemblages.

■ **Regulatory Assessments.** Much of the work done by EPA is regulatory in nature and involves the use of permits to regulate the discharge of various substances into the waters. The Agency does not require the use of biocriteria as numeric regulatory limits in National Pollution Discharge Elimination system (NPDES) permits. It does, however, strongly recommend that states develop and use biocriteria as a permit assessment tool and as a mechanism for evaluating the success of pollution control efforts. Concurrence of biotic data with established biocriteria can be a key measure of permit effectiveness and of regulatory compliance.

■ **Management Planning.** Water resource managers can use the relative relationships of a series of similar streams, as ranked by their compliance with biocriteria, as a means of assigning priorities to their management ef-

forts. In this way budgets and manpower can be applied most effectively because the manager is better informed about the most pressing problems and about those streams most likely to respond to restorative efforts.

■ **Water Quality Project Evaluations.** The measurement of the resident stream biota before, during, and after implementation of pollution management efforts is an excellent way to evaluate the success or failure of those techniques.

■ **Status and Trends of Water Resources.** As states and tribes gather more biological data in support of their biocriteria, their knowledge of the waters becomes more refined. The condition of the nation's waters will be better understood and the direction of change in the various regions will be more evident and better addressed.

To achieve these objectives for the use of biocriteria, EPA is evaluating not only the role of biocriteria in the permit process but also the independent application of various criteria to determine water resource quality. Presently chemical, physical, and biological criteria — when used in a regulatory context — are applied to a waterbody independently. Compliance or lack of compliance with one criterion does not influence the application of another. As biological and other types of criteria, such as sediment criteria (now being investigated) are more widely implemented in state programs, the Agency will continue to investigate the usefulness of weight of evidence approaches as an alternative.

Thus, biocriteria expand aquatic life use designations and improve water quality standards, help identify impairment of beneficial uses, and help set program priorities. Biological surveys (or biosurveys) in conjunction with biocriteria are valuable because they provide

- a direct measure of the condition of the water resource at the site,
- early detection of problems that other methods may miss or underestimate,
- a systematic process for measuring the effectiveness of water resource management programs,
- an evaluation of the adequacy of permits, and
- a measurement of the status and trends of streams over time and space.

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The Development, Validation, and Implementation Process for Biocriteria

Three processes are part of the overall implementation plan to incorporate biocriteria into the surface water programs of regulatory agencies: the development of biocriteria and associated biological survey methods, the validation of the reference condition and survey techniques, and the implementation of the program at various sites within watersheds with subsequent determinations of impairment.

The development of biocriteria by regulatory agencies partly depends on bioassessment to evaluate or compare ecosystem conditions. Bioassess-

ment contains two types of data: toxicity tests and field biological surveys of surface waters. Toxicity tests are described elsewhere (U.S. Environ. Prot. Agency, 1985a,b; 1988; 1989) and are not the subject of this document.

The use of bioassessments to investigate potential impairment, evaluate the severity of problems, ascertain the causes of the problems, and determine appropriate remedial action is a step-by-step process.

Inherent in the process for implementation of biocriteria is the assumption that bioassessment methods have been developed. However, the actual development of biocriteria is the most difficult step in the whole process. A conceptual model for biocriteria development was presented by the U.S. Environmental Protection Agency (1990) to streamline the major elements in the process. This model has been refined for presentation here (Fig. 1-1).

Each component of the model is numbered so that it can be identified and discussed more easily as an important part of the biocriteria development process. Nevertheless, these steps are not sequential. The following paragraphs describe the model process in more detail and identify areas of simultaneous development.

Components 1 through 8 describe the development of biocriteria, prior to their use in regulatory programs.

1. **Investigate the Biocriteria Program Concept.** The biocriteria process involves the selection of several program elements that contribute to effective biocriteria. Each state agency will have its own program objectives and agenda for establishing biocriteria; however, the underlying characteristics for effective biocriteria will be the same in all states.

2. **Formulate the Biocriteria Approach.** Defining biological integrity is the first step in the formulation of a biocriteria program. The activities important to this step are planning the biocriteria process; designating the reference condition; performing the biosurveys; and establishing the biocriteria.

3. **Select Reference Sites or Conditions.** The attainable biological status of an aquatic system is primarily described by the reference condition. If we understand the water resources's biological potential, we can judge the quality of communities at various sites relative to their potential quality. Natural environmental variation contributes to a range in expected conditions; deviations from this range help to distinguish perturbation effects.

   Historical datasets existing from previous studies are also an element of the derived biocriterion. These data range from handwritten field notes to published journal articles; however, biological surveys of present reference sites that are minimally impaired is key to the defined reference condition.

   The selection of reference sites is key to the success of biocriteria development. Various spatial scales can be used, but reference conditions must be representative of the resource at risk and must, therefore, be of the same or similar ecological realm or biogeographic region (i.e., an area characterized by a distinctive flora or fauna).

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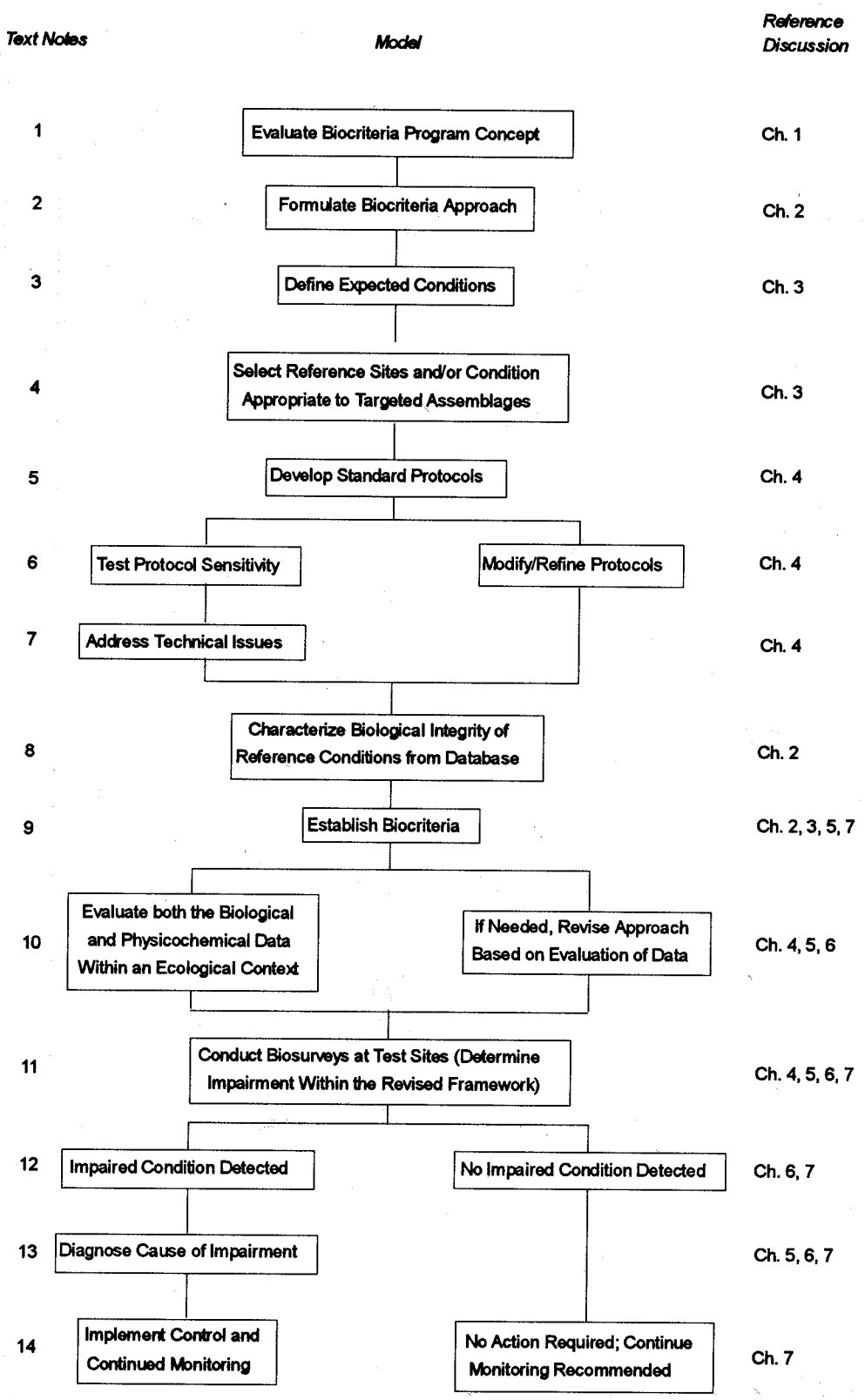

Figure 1-1.—Model for biocriteria development and application.

Candidate reference sites can be selected in a number of ways, but must meet some requirements established on the basis of overall habitat and minimally impaired status in a given region. The reference condition is best described by including data collected from several reference sites representing undisturbed watersheds. Such biological information can be combined for a more accurate assessment of the reference condition and its natural variability. The reference condition approximates the definition of biological integrity unless the reference sites were selected in significantly altered systems.

4. **Select Standard Protocols.** The development of standard protocols requires consensus building relative to the biological and ecological endpoints of interest. The primary goal is to develop measures to assess the biological integrity of aquatic communities in specified habitats, that is, to assess the integrity of the aquatic community as measured by the activities that maintain communities in equilibrium with the environment. There is no correct method to use or biological assemblage to sample; rather, a number of possibilities exist, including the Index of Biotic Integrity (IBI) for fish, and the Rapid Bioassessment Protocols (RBPs) for benthos.

   The process of applying these and other indices across widely differing systems is not a straightforward process and best professional judgment should be exercised before applying them to specific problems. For example, the IBI must be modified for northwestern assemblages since it was developed in the Midwest for midwestern assemblages. These indices measure a structural or functional attribute of the biological assemblage that changes in some predictable way with increased human influence. Combinations of these attributes or metrics provide valuable synthetic assessments of the status of water resources. As the basic theoretical framework and approach should remain consistent, the use of these indices should occur only after rigorous review and evaluation of their documentation. Such reviews are available in a variety of peer-reviewed publications.

The process of applying indices across widely differing systems is not a straightforward process and best professional judgment should be exercised before applying them to specific problems.

5. **Modification and Refinement of the Protocols.** The refinement process is an important step before large-scale biosurveys are conducted. The sensitivity of the protocols should be tested to determine whether differences in community health resulting from anthropogenic activities are discernible from changes caused by other impacts or natural variation. An impact is any change in the chemical, physical, or biological quality or condition of a waterbody caused by external sources. This process applies to all aspects of the protocol from sampling to data analysis and may be repeated as often as necessary.

6. **Address Technical Issues.** Certain technical issues — for example, natural seasonal variability, the aquatic assemblages selected for evaluation, the procedure for selecting sampling sites, and the type of sampling gear or equipment — affect the derivation of biocriteria.

7. **Characterize Biological Integrity.** Analyze biological databases to establish the range of values within the reference condition that will characterize biological integrity. Characterization depends on the use of biological surveys in concert with measurements of habitat structure.

8. **Establish Biocriteria and a Biological Monitoring Program.** Once biological integrity has been characterized and the geographic area regionalized, biological information can be equated to the water quality expectations of the state, and biocriteria can be established for these regions. Biocriteria may vary within a state depending on the region's ecological structure and the type of monitoring used in its water quality programs. Sources for the derived biocriteria are reference sites, historical records, in some instances empirical models of the systems (especially if significantly altered), and the consensus of a representative panel of regional experts evaluating this information.

Step 9 describes the validation of the biocriteria developed in the previous components.

9. **Evaluate and Revise as Needed.** Biocriteria are revised whenever better information is available, natural conditions have changed, and/or the waters of interest have improved. This process includes statistical analyses of biological, physical, and chemical data to establish natural variability and the validity of existing biocriteria. Regional frameworks should be adjusted if biological and geographical data support the need to do so. Reasons for these adjustments and the data used to determine them should be clearly documented.

Steps 10 through 14 describe the use of biocriteria for water resource management, that is, for the assessment, protection, remediation, and regulation of water quality.

10. **Conduct Biosurveys.** Biosurveys conducted at test sites help to determine whether and to what extent a site deviates from the normal range of values observed for the reference condition and from the regional biocriteria. Candidate test sites are any locations along the stream or river in which the conditions are not known but are suspected of being adversely affected by anthropogenic influence.

11. **Detect Impaired and Nonimpaired Conditions.** Decisions on whether adverse or impaired conditions exist must be made, but whether these conditions are socially tolerable may be beyond science. Scientists and resource managers are, however, obliged to determine the relative impairment of the water resource as a precondition for any subsequent decisions.

12. **Review Other Data Sources for Additional Information.** The use of additional data to complement the biological assessment is important in the decision-making process. As part of an integrated approach, whole effluent toxicity (WET) testing, chemical-specific analyses, and physical characteristic measurements can be used to make a comprehensive evaluation.

13. **Diagnose Causes of Impairment.** Once impairment has been determined, its probable causes must be identified before remedial action can be considered and implemented. Probable "causes" may include alteration of habitat structure, energy source, biological interactions, flow characteristics, or water quality. The "source" of the disturbance may be point or nonpoint source contamination or other human activities. Thus, if impairment is detected, the data should be evaluated to determine its probable causes; the site and surrounding area should be investigated for other probable causes; additional data should be collected; and either remedial action should be formulated (if the actual causes have been determined) or the investigation should be continued.

14. **Implement Remedial Actions and Continue Monitoring.** If probable causes have been identified so that an action plan can be developed, the last step is to begin remedial measures and continue monitoring to assess the stream's recovery. This step can be used to evaluate management programs and to determine cost-effective methods. The relative success of the measures depends on the selection of appropriate remedial actions to reduce or eliminate impairments and to attain the designated uses that the biocriteria protect.

    If no impairment is found, no action is necessary except continued monitoring at some interval to ensure that the condition does not change adversely.

Characteristics of Effective Biocriteria

Generally, effective biocriteria share several common characteristics. Well-written biocriteria

- provide for scientifically sound evaluations,
- protect the most sensitive biota and habitats,
- protect healthy, natural aquatic communities,
- support and strive for protection of chemical, physical, and biological integrity,
- include specific assemblage characteristics required for attainment of designated uses,
- are clearly written and easily understood,
- adhere to the philosophy and policy of nondegradation of water resource quality, and
- are defensible in a court of law.

In addition, well-written biocriteria are set at levels sensitive to anthropogenic impacts; they are not set so high that sites that have reached their full potential cannot be rated as attaining, or so low that unacceptably impaired sites receive passing scores. The establishment of formal biocriteria warrants careful consideration of planning, management, and regulatory goals and the best attainable condition at a site. Stringent crite-

ria that are unlikely to be achieved serve little purpose. Similarly, biocriteria that support a degraded biological condition defeat the intentions of biocriteria development and the Clean Water Act. Balanced biocriteria will incorporate multiple uses so that any conflicting uses are evaluated at the outset. The best balance is achieved by developing biocriteria that closely represent the natural biota, protect against further degradation, and stimulate restoration of degraded sites.

Additional general guidance regarding the writing of biocriteria is provided in U.S. Environ. Prot. Agency (1990). Several kinds of biocriteria are possible and vary among state programs. Both narrative and numeric biocriteria have been effectively implemented. Both should be supported by effective operational guidelines and adequate state resources, including people, materials, methods, historical data, and management support.

The best balance is achieved by developing biocriteria that closely represent the natural biota, protect against further degradation, and stimulate restoration of degraded sites.

Narrative biocriteria consist of statements such as "aquatic life as it should naturally occur" or "changes in species composition may occur, but structure and function of the aquatic community must be maintained." An aquatic community, the association of interacting assemblages in a given waterbody, is the biotic component of an ecosystem. Numeric values, such as measurements of community structure and function, can also serve as biocriteria. The numeric criterion should be a defined range rather than a single number to account for a measure's natural variability in a healthy environment. It may also combine several such values in an index. General examples of actual narrative and numeric biocriteria from selected state programs are presented in the following section; the information was taken from *Biological Criteria: State Development and Implementation Efforts* (U.S. Environ. Prot. Agency, 1991a).

Examples of Biocriteria

Five states have adopted definitive biocriteria for water quality management. Maine and North Carolina use narrative criteria; Ohio and Florida have implemented combined narrative and numeric criteria. Delaware has defined biocriteria for estuarine waters, and most other states have programs in various stages of development.

Narrative Biological Criteria

States may draft general narrative biological criteria early in their program — even before they have designated reference sites or refined their approach to biological surveys.

States may draft general narrative biological criteria early in their program — even before they have designated reference sites or refined their approach to biological surveys. This haste does not mean that having reference sites and a refined system for conducting surveys is unimportant; it means that a biocriteria program begins with writing into law a statement of intent to protect and manage the water resources predicated on an objective or benchmark, for example, "aquatic life shall be as naturally occurs."

When the objective to restore and protect the biological integrity of the water resources has been formally mandated, then the operational meaning of the statement and the identification of the agency responsible for developing the necessary procedures and regulations can be stipulated as the state's first steps toward the development of narrative and numeric biological criteria. The key point is that natural or minimally impaired water resource conditions become the criteria for judgment and manage-

ment. For more specific information on this concept and its implementation, see the EPA guidance document "Procedures for Initiating Narrative Biological Criteria" (Gibson, 1992).

Narrative biological criteria form the legal and programmatic basis for expanding biological surveys and assessments and for developing subsequent numeric biological criteria.

Maine and North Carolina are examples of the practical development and use of narrative biological criteria. Maine incorporated the general statement "as naturally occurs" into its biocriteria, but also developed supporting statements that specified collection methods to survey aquatic life. Maine uses narrative biocriteria defined by specific ecological attributes, such as measures of taxonomic equality, numeric equality, and the presence of specific pollution tolerant or intolerant species.

North Carolina uses narrative criteria to evaluate point and nonpoint source pollution and to identify and protect aquatic use classifications. In North Carolina, macroinvertebrate community attributes are used to help define use classifications. These attributes include taxonomic richness and the biotic indices of community functions and numbers of individuals. They are also used in conjunction with narrative criteria to determine "poor," "fair," "good–fair," "good," and "excellent" ratings for the designated uses.

Narrative biological criteria cannot be fully implemented without a quantitative database to support them.

Narrative biological criteria specify the use designations established by the state and describe the type of water resource condition that represents the fulfillment of each use. Conversely, when adopted by the state and approved by EPA, they become one of the standards by which water resource violations are determined.

Nevertheless, narrative biological criteria cannot be fully implemented without a quantitative database to support them. Quantitative data provide a responsible rationale for decision making and assure resource managers a degree of confidence in their determinations. In fact, some states have elected to develop narrative biocriteria and to use this legislative mandate to establish administrative authority for their quantitative implementation in a state natural resources agency. In this manner, future improvements in scientific methods and indicators can be accommodated through the administraive process rather than the more cumbersome and expensive method of amending state laws.

These data are similar to the data used to formulate numeric biological criteria; they can and should include the determination of reference conditions and sites. Thus, when the survey process for narrative biocriteria is well developed and refined, the program can easily begin the development of numeric biocriteria. While not an essential precursor, the narrative process is an excellent way for states to begin expanding their stream resource evaluation and management procedures to include more definitive numeric biocriteria.

Numeric biocriteria include discrete quantitative values that summarize the status of the biological community and describe the expected condition of this system for different designated water resource uses.

Numeric Biological Criteria

Although based on the same concept as narrative biocriteria, numeric biocriteria include discrete quantitative values that summarize the status of the biological community and describe the expected condition of this system for different designated water resource uses.

The key distinction between narrative biocriteria supported by a quantitative database and numeric biocriteria is the direct inclusion of a specific value or index in the numeric criteria. This index allows a level of specification to water resource evaluations and regulations not common to narrative criteria.

To develop numeric criteria, the resident biota are sampled at minimally impaired sites to establish reference conditions. Attributes of the biota, such as species richness, presence or absence of indicator taxa, and distribution of trophic groups, help establish the normal range of the biological community as it would exist in unimpaired systems.

Ohio combines narrative and numeric biocriteria and uses fish and invertebrates in its stream and river evaluation programs. Its numeric biocriteria are defined by fish community measurements, such as the Index of Well-Being (IWB) and the Index of Biotic Integrity (IBI). Ohio also employs an Invertebrate Community Index (ICI). All three measures provide discrete numeric values that can be used as biocriteria.

Ohio's numeric criteria for use designations in warmwater habitats are based on multiple measures of fish and benthic macroinvertebrates in different reference sites within the same ecoregion. Macroinvertebrates are animals without backbones that are large enough to by seen by the unaided eye and caught in a U.S. Standard No. 30 sieve. Criteria for this use designation are set at the 25th percentile of each biological index score recorded from the established reference sites within the ecoregion. Exceptional warmwater habitat criteria are set at the 75th percentile from the statewide set of reference sites (Ohio Environ. Prot. Agency, 1987). Use of the 25th and 75th percentiles, respectively, portrays the minimum biological community performance described by the narrative use designations. Such applications require an extensive database and multiple reference areas across the stream and river sizes represented within each ecoregion.

To develop the most broadly applicable numeric biological criteria, careful assessments of biota in multiple reference sites should be conducted (Hughes et al. 1986). The status of the biota in surface waters may be assessed in numerous ways. No single index or measure is universally recognized as free from bias. Evaluating the strengths and weaknesses of different assessment approaches is important, and a multimetric approach that incorporates information on species richness, trophic composition, abundance or biomass, and organism condition is recommended (see Chapter 6).

Other Biocriteria Reference Documents

EPA has developed several program and technical guidance documents for implementing biocriteria beginning with a preliminary discussion of biocriteria program development issues: legislative authority, steps in developing biocriteria, and the application of biocriteria to surface water management (U.S. Environ. Prot. Agency, 1990).

A survey of existing state programs was conducted in 1990 to delineate the status of bioassessment implementation on a national basis (U.S. Environ. Prot. Agency, 1991a). In addition, a reference guide to the technical literature pertaining to biocriteria has been developed (U.S. Environ.

Prot. Agency, 1991b). The latter contains cross-references to technical papers that develop the concepts, approaches, and procedures necessary to implement habitat assessment and biological surveys in the development and use of biocriteria. In December 1990, a symposium on biological criteria provided a forum for discussing technical issues and guidance for the various surface waterbody types. The proceedings from this conference are presented in U.S. Environ. Prot. Agency (1991d). Most recently, the agency has developed guidance to help states initiate narrative biological criteria (Gibson, 1992).

To develop numeric biocriteria, the resident biota are sampled at minimally impaired sites to establish reference conditions. Attributes of the biota such as species richness, presence or absence of indicator taxa, and distribution of trophic groups are useful for establishing the normal range of biological community components as they would exist in unimpaired systems.

Suggested Readings

Gibson, George. 1992. Procedures for Initiating Narrative Biological Criteria. EPA-822-B-92-002. U.S. Environ. Prot. Agency, Washington, DC.

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